DESIGN AND MANUFACTURE OF A ONE CAVITY MOULD FOR CASTING PISTON

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ABSTRACT
In this paper, we design and manufacture a one cavity mould for the casting of a piston by sorting materials locally. The mould was also fabricated after the design calculations using basic machine tools like lathe, milling and drilling machines. Test conducted on the mould reveals sound casting with little or no defects

KEYWORDS: Permanent mould casting, Shrinkage allowance, Gates, Piston

Nigeria as a developing nation needs to be self reliant in all aspects of economic activities, which includes construction, manufacturing and other engineering endeavour (Nwachukwu, 1997). Manufacturing is undoubtedly one of the most important sectors of national economics as it creates wealth (Ibhadode, 2001).often times, one hears of plants not functional due to lack of spares parts which cannot be supplied by the original vendors of the plant because of its obsolescence. Casting provides a veracity and flexibility that have maintained casting position as a primary production method for machine elements. As Nearly sixty – five million tonnes of cast components worth more that $100 billion are produced annually for automobile, industrial machinery, municipal fittings and many other sectors, by over 30000 foundries worldwide. Large numbers of companies are involved in designing, machining, testing and assembling cast components and in related activities such as tool making and material supply (Ravi, 2003)

Casting processes are divided according to the specific type of moulding method used in the casting
Follows: sand centrifugal, permanent die, plaster-mold and investment. As demand for quality castings in production quantities increased, the attractive possibilities of metal melds brought about the development of the permanent-meld process. Although not as flexible regarding design as sand casting, metal-mold casting made possible the continuous production of quantities of casting from single meld as compared to batch production of individual sand melds.

In permanent-mould castings, both metal melds and cores are used, the metal being poured into the meld cavity with the usual gravity head as in sand casting. Moulds are normally made of dense iron, large cores of cast iron and collapsible cores of alloy steel. All necessary spruses, runners gates and risers must be machined into the meld and the meld cavity itself is made with the usual metal shrinkage meld is usually composed of one, two or more parts, which may swing or slide for rapid operation. Whereas in sand casting the longest dimension is always placed in a horizontal position (Benjamin and Richard 1989). While in permanent-meld casting the longest dimension of a part is normally placed in a vertical position.

The aim of this paper is to design and manufacture one cavity permanent mould for casting an internal combustion engine piston

THE OBJECTIVES INCLUDE:
1. To design one cavity permanent –mould
11 To manufacture the mold

METHODOLOGY: The mould material shall be obtained from steel shop. the design of the mould shall be based on the consideration of shape size, shrinkage allowances, casting material, production economies. The mould shall be manufactured by machining operations which shall include milling, boring, drilling, and turning.

PISTON DATA

1. Crown external diameter 49mm
2. Crown internal diameter 46mm

3. Crown thickness 3mm
4. Skirt internal diameter 50
5. Skirt thickness 45
6. Piston height 56
7. Pin hole diameter 10
8. Pin hole length 8
9. 1st land thickness 1.5
10. 2nd land thickness 1.5
11. 1st groove 1
12. 2nd groove 1
13. Piston material Aluminium
14. Material density 2.7 x 10^3 kg/m^3
15. Piston mass 0.04kg
16. Corresponding piston volume

PATTERN ALLOWANCES

The following allowances are provided for

i. Shrinkage allowances arising from solidification and contraction of the molten metal to be cast
ii. Machine and draft allowance

Below show the pattern shrinkage, volumetric and machine finish allowances.

The works of Boothryod (1982) ,Ibhadode (2001) and Ravi (2003), have recommended the following pattern allowances (for aluminium base) for gravity die casting: from table, 1, 2 and 3

Linear shrinkage allowance 0.013mm

Machine finish allowance 1mm

Mould cavity size

GATING SYSTEM

The functions of an ideal gating system are to

- Feel the meld cavity
- Introduce molten metal into the meld with as little turbulence as possible to prevent meld erosion and gas pick-up.
- Established the best possible temperature gradients in the casting
- Introduce proper skimming action on the metal as it flows through the spruce system.
- Regulate rate of entry of metal into the meld cavity.

In order for gates to function properly, one must control

- Rate of pouring.
- Size, number and location of gates leading to the cavity.
- Size and type of spruce and runner.
- Temperature (fluidity) of the metal
- Position of the mould during casting and freezing .
- In the design of the gates two basic fluid flow equations are of interest
- Calculation of metal velocity and flow rates
- To understand the fundamentals of metal flow in gating systems.

The first of these laws is law of continuity which may be written

$$Q = A_1V_1 = A_2V_2$$
$$where\ Q = metal\ flow\ rate$$
$$A_1 = cross - sectional\ area\ of\ flow,$$
$$V_{K_2} = velocity\ of\ metal\ flow\ at\ point\ 1 and\ 2$$

The second law or equation basic importance in flow calculations is Bernoulli equation. It states that the energy of a liquid at a given point can be separated into parts,$energy\ of\ velocity \left({v^2}/{2g}\right)$,

$$energy\ of\ position\ (h) and\ energy\ of\ pressure\left({}^{\rho_1}/_{\tau}\right).$$

In real gating systems, substantial energy losses occur at all channel entrances and exits, at bends,enlargements,contractions and even smooth channel due to frictional effects.bernoulli's equation can be modified to account for these losses by addition of appropriate terms to the equation. In this design, energy loss (per unit weight of metal is given)

$$h_f = \frac{fL}{d}\left(\frac{v^2}{2g}\right)$$

Energyy loss at bend

$$h\emptyset = k\left(\frac{v^2}{2g}\right)$$

These energy terms can be added to Bernoulli's equation in such a way as to describe the flow characteristics in any real system

RESULT

The one cavity mould for casting piston was successfully design, manufactured and tested. The casting efficiency was satisfactorily and the cast was found to be sound with little or no defects.

TABLE 1 Pattern shrinkage allowances (Ibhadode,2001)

Casting Alloys	Pattern Dimension (Mm)	Type Of Construction	Section Thickness Mm	Contraction Mm/Mm
Gray casting iron	Up to 610 From 635-1220 From 635-1220 Over 915	Open - - Core Construction -		0.01042 0.00833 0.0694 0.01042 0.00833 0.00694
Steel Casting	Up to 610 From 635-1839 Over 1830 Up to 460 From 480-1220 From 1245-1675 Over	Open construction - Cored Construction - - -		0.02083 0.01563 0.01302 0.02083 0.01563 0.01302 0.01042
Malleable cast iron			1.5 3 4.5 6 9.5 12 16 19 22 25	0.01432 0.01302 0.01237 0.01172 0.01042 0.0911 0.00781 0.00651 0.00391 0.00260
Aluminium	Up to 1220 From 1245-1830 Over 1830 Up to 610 Over 1220 635 to 1220	Open Construction - - Cored Construction -		0.01302 0.01172 0.01042 0.01302 0.01172 0.01042 0.0052
Magnesium	Up to 120 From 1245-1830	Open construction		0.05729 0.01302

	Over 1830 Up to 610 Over 1220 635 to 1220	cored construction - -		0.01302 0.01302 to 0.01042
Brass				0.01563
Bronze				0.0142-0.102083

Table 2 pattern machine finish allowance (Ibhadode,2001).

Casting alloys	**Pattern size(mm)**	**Bore (mm)**	**Finish(mm)**
Cast iron	Up to 300 330-610 635-1070 1090-1525 1550-2030 2060-3050	3 5 6 8 9.5 11 Special instruction	2.5 3 5 6 8 9.5 Special instruction
Cast steel	Up to 300 300-610 635-1070 1090-1525 1550-2050 Over 3050	5 6 8 9.5 12 16 Special instruction	3 5 8 9.5 11 12Special instruction
Malleable iron	Up to 150	1.5 2.5 2.5 4.5 5 Special instruction	
Brass, bronze and aluminium alloy castings	Up to 300 300-610 635-915 Over 915	2.5 5 5 Special instruction	1.5 3 4 Special instruction

Table 3 volumetric shrinkage (Hong Kong university,2003).

Metal	**Shrinkage Allowance(%)**
Aluminium Gray cast iron Gray cast iron, high carbon Low carbon cast steel Bronze (Cu-Sn)	7 1.8 0 3.0 4.5 5.5

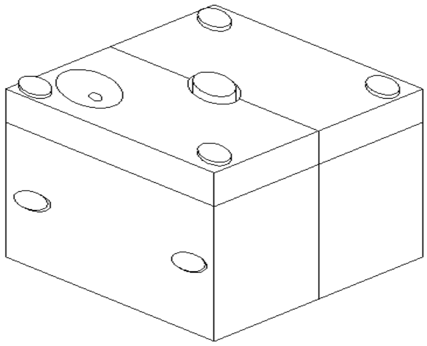

Fig 1: Isometric view

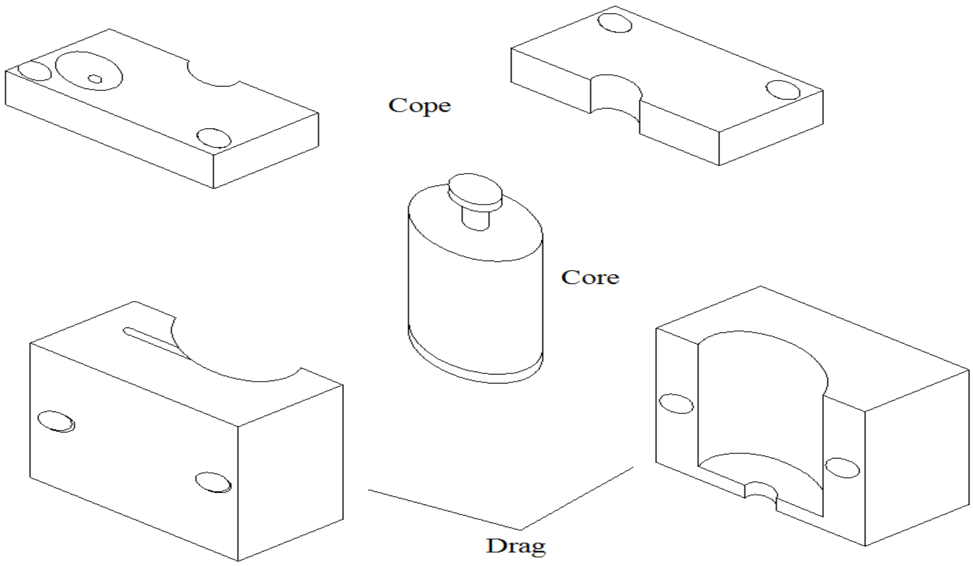

Fig 2: Drawing showing different parts

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